ATTACHMENT 1

Mini-Case Studies

of Air Toxics Monitoring and Modeling

This is a compendium of mini-case studies of air toxics monitoring and modeling projects at different scales and in different locations. It is meant to provide some sense of the range of monitoring and modeling approaches that has been used and contacts where you can get more information on specific projects of interest. We hope that people will add suggestions for projects that could be written up and added to this group and even provide write-ups in the format that is being used. The more case studies there are, the richer the resource will be.

Questions, suggestions, and contributions can be addressed to the following::

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CONTENTS

1. Atsugi, Japan

The Shinkampo Incinerator in Atsugi Japan Case Study

I. Brief Overview

The United States Naval Air Facility at Atsugi, Japan (NAF Atsugi) is located in the Kanto Plain area on the island of Honshu, Japan. Directly to the south of the facility, in the Tade River Valley, was the Shinkampo Incinerator Complex (SIC). The Incinerator is no longer in operation, having closed in May of 2001. While operating, three incinerators were licensed by Japan to burn general industrial waste and infectious industrial waste (medical), and were incinerating up to 90 tons a day. The pollution control devices included precipitators and scrubbers. The 4-5 acre facility was located in a small river valley, and the NAF Atsugi is positioned on a plateau at the end of the valley. While the incinerator stacks were about 25 m high from the valley base, they were only about 15 m higher than the ground level of the NAF Atsugi. Further, these stacks were only 250 m away from the nearest high-rise housing unit and about 1000 m from a school and day care center. The predominant wind direction is from south to north during the spring and summer; conversely from north to south during the fall and winter. When blowing from south to north, the plume moves directly onto the base where exposures could occur. The NAF Atsugi was not permitted to test the stacks, and was not provided with stack test information by the owners of the facility. Subsequently, their evaluation of environmental impacts focused on environmental monitoring on NAF Atsugi, including extensive air and soil testing programs. Numerous organic and inorganic contaminants were measured in these programs. Also, the Navy conducted additional analyses to understand the origin of what they were measuring. Specifically, wind speed and direction measurements were taken along with all air monitoring data, as well as observational data regarding the incinerator operation (operating/shut down, color of smoke in plume, etc.). Interestingly, they found that only a handful of the measured contaminants could be unambiguously attributed to the incinerator, including dioxins, PM10, hydrochloric acid, lead, cadmium, and arsenic. Some important risk driving contaminants, such as benzene, showed much less correlation with wind direction suggesting other on-base sources, such as the regular deployment of the airplanes as part of the airbase operations. To further enhance their understanding of exposure and incinerator emissions, they also conducted air dispersion modeling using ISC3. Using the network of air measurements and the wind speed data, they calibrated the ISC3 on several contaminants including dioxin to be able to estimate on stack emission rates, and to develop a refined concentration term for human exposure assessment. Interestingly, dioxin emissions were estimated to total 18 g TEQ/yr, which is not particularly high for incinerators, although air concentrations are some of the highest regularly measured in the world. This was because of the low height of the stack and the proximity to exposure locations.

The National Center for Environmental Assessment (NCEA)/ORD was enlisted to support the Navy in their efforts at this site in 1997, mostly in their interpretation of dioxin air data, design of a dioxin soil testing program, and assessing risk due to dioxin exposure. The Navy is expected to finalize its comprehensive risk assessment on this site during 2002, and to

then make publicly available its extensive wealth of monitoring data and modeling studies.

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III. Uses of modeling and monitoring

This is a unique example where modeling was only used to supplement an extensive monitoring program. In many circumstances such as this one, stack test information is combined with modeling to understand exposure. Because of the cost and other factors such as uncertainty (enough samples? downwind conditions?, and so on), monitoring is usually not relied upon for exposure assessing and most often just used to verify, or "truth test" results of modeling. In this case, however, literally millions of dollars were spent determining exposure point concentrations for exposure and risk assessing.

IV. Key Results

Two abstracts containing dioxin air and soil data have been submitted to the Dioxin 2002 conference, to be held in August of 2002. NAF Atsugi contractor reports have additional information.

Figures showing percent of time wind was blowing from the incinerator to the air monitor, clearly showing the impact of the incinerator ---->

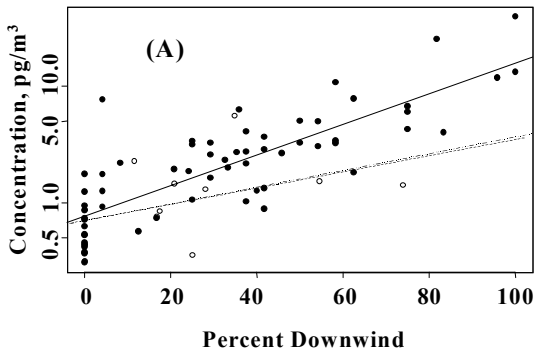

Table 1. Summary of TEQ results for the categories of soil samples.

Description	n	TEQ, pg/g	TEQ range
Exposure Study Areas	28	15	<1 - 90
Reference Study Areas	12	27	13 - 62
Trend - downwind and impacted	11	266	66 - 642

Trend - all other samples	22	14	8 - 83

Descriptions: “Exposure Study Areas” - locations such as schools, apt building where exposure could occur; “Reference Study Areas” - remote sites on NAF Atsugi where only deposition would likely have caused soil elevations, if any; “Trend - Downwind & Impacted” - all trend samples were randomly spaced in a study design to evaluate trends. The downwind & impacted samples were a cluster of 11 samples all downwind and near, within 300 meters, to the incinerator. The other 22 trend samples were spaced up to a kilometer away from the incinerator.

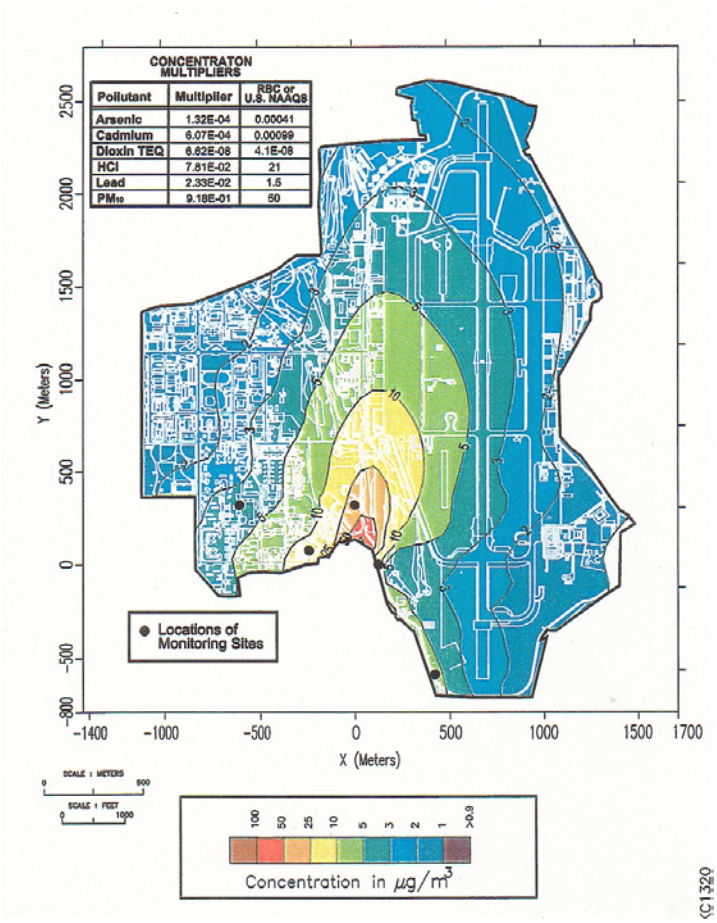

Figure showing the results of the air monitoring exercise, for the 6 contaminants unambiguously originating from the incinerator. The concentrations are modeled concentrations per g/sec unit emissions. These measurements get multiplied by the “multiplier” identified to get predicted air measurements.

VI. Lessons Learned

The fact that stack monitoring was not allowed made this a unique circumstance where ambient air monitoring, wind speed/direction monitoring, and modeling were used to understand exposure to this source. The air monitoring was extremely expensive, but may have been uninformative had not wind speed and direction measurements accompanied all air concentration measurements. Certainly in every similar circumstance, all efforts must be made to conduct stack sampling to understand what is being emitted from the source.

2. Columbus, OH

Columbus Municipal Solid Waste Incinerator Case Study

I. Brief Overview

In 1992, a stack test revealed that the Columbus Municipal Solid Waste-to-Energy Incinerator (WTE) was emitting at a rate equal to about 1000 grams of dioxin toxic equivalents (TEQs) per year. To put this in perspective, EPA's Dioxin Sources Inventory estimated that all known and quantified sources were emitting about 12,000 g TEQ/yr in 1987 and 3,000 g TEQ/yr in 1995. As a result of this alarming stack test, Region 5 began developing the scientific basis for an Emergency Order to require the owners of the Columbus WTE to install MACT controls well ahead of the federally-mandated schedule. The Region enlisted the National Center for Environmental Assessment (NCEA)/ORD to assist in the conduct of a risk assessment on the impacts of these dioxin emissions. This assessment entailed use of air modeling (using stack emission data) to simulate the arrival of dioxins at nearby farms, the routing of these dioxins through the food chain, and finally the estimation of exposure and risk to a farm family consuming home-grown foods. The Emergency Order was instated in 1994, and it required the owners of the Columbus WTE to install MACT by 1997. During 1994, owners of the Columbus WTE made some process changes (temperature of combustion, installation of quenches) in an attempt to reduce dioxin emissions. To evaluate the effectiveness of these procedures, additional stack tests and ambient air monitoring were conducted by the State of Ohio EPA in the spring and summer of 1994. In December of 1994, the Columbus WTE shut down, citing lack of funding to maintain operations, much less comply with the Emergency Order to install MACT. In 1995, the Region enlisted the support of NCEA in the design of a soil monitoring study to understand the potential long-term impacts of dioxin emissions. NCEA has continued to use this wealth of data to study the relationships between dioxin emissions and environmental impacts. One evaluation focused on the relationships between all the media which had been sampled, including stack emissions, incinerator ash, air, and soil. A second evaluation used the stack emission, air, and soil data in model validation/calibration exercise. This exercise involved use of the ISC3 model, to see how well it would predict measured dioxin air concentrations, and then it used predicted deposition rates in a soil concentration model to see how well predicted soil dioxin concentrations would match measured concentrations.

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III. Uses of modeling and monitoring

This case study represents a comprehensive example of the interplay between modeling

and monitoring, and even more, how these exercises and evaluations play into the regulatory decision-making process at EPA. Such efforts are possible, and maybe uniquely possible, with the suite of compounds generally called "dioxin-like compounds" or just "dioxins", for these reasons: 1) dioxins are one of the most toxic chemicals ever produced by man, and as such, one of the best studied class of compounds for human health effects, environmental fate, human exposure, source characterization, and other disciplines, 2) dioxins are persistent in the environment, including in air, soils, and sediments, and they bioaccumulate in terrestrial and aquatic animals. This increases the likelihood of success for just about any monitoring program. 3) these same tendencies for persistence and bioaccumulation also make dioxin the ideal class of compounds to model. The models are being used to predict long-term trends, which tends to be an easier chore than asking them to predict short term events.

IV. Key Results

The results from the Columbus WTE studies by NCEA are covered in three publications. These publications and a sample of some of the results are:

1. Lorber, M.; Cleverly, D.; Schaum, J. 1996. A screening level risk assessment of the indirect impacts from the Columbus waste to energy facility in Columbus, Ohio. Proceedings of an International Specialty Conference, sponsored by the Air and Waste Management Association and the United States Environmental Protection Agency, held April 18-21, 1996 in Washington, D.C. published in, Solid Waste Management: Thermal Treatment & Waste-to-Energy Technologies, VIP - 53. pp. 262-278. Air & Waste Management Association, One Gateway Center, Third Floor, Pittsburgh, PA 15222.

Exposure and risk results for the Columbus WTE risk assessment.

Exposure Pathway	Lifetime Average Daily Dose ng TEQ/kg-day	Excess Cancer Risk
Soil Dermal Contact	$6*10^{--8}$	$9*10^{-9}$
Vegetable Ingestion	$1*10^{-5}$	$2*10^{-6}$
Inhalation	$6*10^{-6}$	$9*10^{-7}$
Beef Ingestion	$1*10^{-3}$	$2*10^{-4}$
Milk Ingestion	$5*10^{-4}$	$8*10^{-5}$

2. Lorber, M, P. Pinsky, P. Gehring, C. Braverman, D. Winters, W. Sovocool. 1998. Relationships between dioxins in soil, air, ash, and emissions from a municipal solid waste incinerator emitting large amounts of dioxins. Chemosphere, Volume 37:2173-2197.

Result: Isolines of equal soil TEQ concentration around the Columbus WTE location:

3. Lorber, M., A. Eschenroeder, R. Robinson. 2000. Testing EPA's ISCST-Version 3 Model on Dioxins: A comparison of predicted and observed air and soil concentrations. Atmospheric Environment 34:3995-4010.

Results: Isolines of predicted air concentrations compared against measured air concentrations of TEQ for one sampling date in March, 1994.

VI. Lessons Learned

If encountering a similar situation - an incinerator emitting large amounts of dioxin-like compounds - here are some of the things we can do differently and better to understand and remedy the situation:

1) More air sampling within 1 km while incinerator is operating to better understand the plume.
2) Search for more exposure matrices to sample, such as impacted farm animals (cows, free range chickens).
3) If the incinerator has been operating long enough, consider identifying and sampling blood of a potentially exposed population along with a control population.
4) Further study the environmental transformations of specific dioxin-like compounds from source to environmental matrix (soil particularly).

3. Kenova, KY, WV, OH

Tri-State Geographic Initiative Case Study

1. Tri-State Geographic Initiative

- Located along the Big Sandy and Ohio Rivers at the convergence of Kentucky, West Virginia, and Ohio
- Sponsored by:
  Ohio Environmental Protection Agency
  West Virginia Division of Environmental Protection
  Kentucky Department for Environmental Protection
  U.S. Environmental Protection Agency Regions 3, 4, and 5

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III. In 1991, Kentucky, West Virginia, Ohio, and the United States Environmental Protection Agency partnered to study environmental problems in the highly industrialized area where the three states meet. This project came to be known as the **Tri-State Geographic Initiative or TGI.** Public concern, and the availability of time, resources, and data led the partners to focus on the impact of air, drinking water, and fish consumption on human health in the area.

This case study will focus on air quality which emerged as a priority in the study. The TGI technical steering committee established the Air Toxics Project through which air monitoring, dispersion modeling, and assessment of risks associated with these air pollutants was carried out. The results of these analyses will help set priorities for improving environmental quality and public health in the area.

Resource constraints made it impossible to study the entire 2300 square mile area concurrently, so the major sources of air pollution in the area were grouped into six clusters which could be studied individually. One of these clusters consisted of several industrial sources in the Kenova, West Virginia area. The Kenova cluster study area straddles the banks of the Big Sandy River, and includes not only industrial complexes (including a refinery), but also residences, schools, day care, and other commercial concerns.

IV. Air monitoring and modeling were conducted for the July 1996 to July 1997 period.

- Monitoring:
  - 7 fixed sites sampled every 12-14 days for volatile organic chemicals, semi-volatile organic analytes, metals, and acid/base gases to assess chronic human health concerns. A triggered sampler was located at one of the fixed locations to collect VOC samples when concentrations were elevated.
  - A mobile laboratory collected continuous VOC samples over 15 weeks at 4 locations to assess acute risks

- Modeling
  - Area specific meteorological data were collected
  - Air quality effects were modeled based on reported releases from four major chemical facilities in the Kenova area using four scenarios:
    - ✓ Daily meteorological data and highest reported emissions to represent a worst case scenario
    - ✓ Daily meteorological data and daily emissions to represent a typical scenario
    - ✓ Daily meteorological data and daily emissions during periods when episodes were known to have occurred
  - Emissions from mobile sources and small businesses were not modeled

V. Results

- Long-term air monitoring
  - Hazard indices exceeded 1 at all stationary sampling sites indicating an area-wide concern for non-cancer effects in humans with chromium being a the primary contributor to the risk
  - All sampling sites exceeded 1E-6 cancer risk, and all but one site were lower than 1E-4 cancer risk, with benzene and chromium driving the risk

- Modeled air risks
  - Of the 4 facilities analyzed, only one had modeled emissions that resulted in risks above the levels set in the risk management plan(hazard index > 1, or cancer risk > E-6)

VI. Monitoring vs. Modeling Lessons Learned

- At air monitoring locations, risks predicted based on air monitoring results tended to be higher than risks estimated based on modeling results
- Modeling indicates that highest modeled industrial source risks are near facility boundaries, and that risks are typically lower in residential areas further removed from the facilities.
- Modeling results are only as good as the data provided by the industries, some of which are supportive, and some of which may provide only typical or average data

- Modeling can provide a better indication of daily values, since monitoring does not occur every day and may miss episodic emissions.
- Modeling allows the pinpointing of sources of particular chemicals; monitoring reports values that are a composite of emissions from many sources
- Because relatively few such studies have been conducted, interpreting the results is difficult - Were these results typical or atypical nationally? Would a plant-specific, regional, or national policy be most appropriate to address the risks?

4. Los Angeles International Airport

I. **Project name and location, also project sponsor**: Los Angeles World Airports: Air Quality and Source Apportionment Study of the Area Surrounding Los Angeles International Airport:

Vol I. Technical Work plan, Vol. II. Quality Assurance Project Plan were prepared for LAWA using contractors from CDM and academic experts (John Watson, Desert Research Institute, and Ron Henry, University of Southern California), dated November 10, 2000. Both are draft pending external peer review funded by EPA to be complete in a peer review workshop expected to occur @ July 2002. Winona Victery is the contact in Region 9; EPA is funding peer review; further implementation will require Federal funding (expected to be $470,000 for one-month pilot) and year-long study $2-3,000,000. LAWA unable to fund after 9/11.

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III. Key questions addressed and purpose of the project:

Los Angeles World Airports (LAWA) proposes to conduct an air quality study to develop detailed information about the role of the Los Angeles International Airport (LAX) in emitting air pollutants and the impact the emissions have in the neighborhoods around LAX. This is the first attempt at performing such study near an airport.

IV. Uses of modeling and monitoring: Emissions data collected by both on-site and off-site monitoring and comprehensive characterization of emission sources and mass emissions with those sources for facilities. Source apportionment techniques will include chemical composition receptor modeling, spatial gradient analysis, time series analysis, emissions inventory development, and air dispersion modeling. Monitoring will be performed to identify source-dominated baseline site and neighborhood sites. Analytes include gases, particle mass and chemistry, substrate sampling, and meteorology.

Dispersion modeling will attempt to determine how much of each pollutant of concern in nearby neighborhoods is contributed by LAX relative to non-LAX emitters, what is the uncertainty of these source contributions? What are the dominant source categories that contribute to each pollutant of concern from LAX and non-LAX emitters? How do source contributions from different source types differ by time of day, day of week, and time of year?

V. Key results (and were the results useful to the sponsor?)

Study is on hold pending external peer review and availability of funds.

VI. Lessons learned (and what would you have done differently?)

LAWA contractor hired monitoring and modeling experts at the request of the LAX Technical Work Group to draft the technical work plan. EPA and State of California Air Resources Board, and South Coast Air Quality Management District, and FAA served on this workgroup. Work by the first group of LAWA staff was poor and the lead Camp Dresser McGee consultant was hired by the airport to replace the LAWA staff. LAWA agreed to accept EPA and California Air Resources Board recommendations for external authors. The Technical Work Group who had recommended the experts then had to wait for the re-draft of the original document. EPA, CARB and South Coast AQMD did not feel comfortable asking for peer-review of the LAWA-funded document. When LAWA funding was no longer available, the airport had already committed publicly about performing this study with EPA oversight, we agreed that external peer review was necessary and that EPA could fund that. LAWA has been hopeful that we can still perform the Air Quality and Source Apportionment Study.

5. Milwaukee, WI, and Sacramento, CA

I. Testing of a Model to Predict Human Exposure to Aldehydes Arising from Mobile and Point Sources. EPA STAR Grant No. R 826787-01-0

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III Key questions addressed and purpose of the project.

The main hypothesis to be tested is that a mathematical model can be used to predict personal exposure distribution to aldehydes. Additional hypotheses to be tested are that (a) personal exposure levels of aldehydes exceed outdoor concentrations; (b) indoor aldehyde concentrations exceed outdoor concentrations; and (c) the composition of oxygenated fuel results in significant differences in population exposures to aldehydes.

IV. Uses of Modeling and Monitoring

Milwaukee, Wisconsin (because of the use of ethanol in the gasoline) and Sacramento, California (because of the use of methyl *t*-butyl ether or MTBE) were chosen for the field studies. These two field studies, conducted for approximately 40 days each during the summers of 1999 and 2000, were both directed towards acquiring representative personal monitoring data that will be used to estimate the exposures of urban and suburban residents to selected aldehydes, volatile organic compounds (VOCs), and carbon monoxide (CO). Aldehydes (formaldehyde, acetaldehyde, acrolein, propionaldehyde, butyraldehyde, crotonaldehyde, glyoxal, methylglyoxal) were sampled using DNPH silica cartridges, VOCs (ethanol, MTBE, benzene, toluene, xylenes) were sampled using sorbent tubes, and CO was measured using real-time monitors. Air exchange in each home was evaluated.

Through the collection and analysis of VOCs and CO in addition to the aldehydes, the design permits a source apportionment of the aldehyde contribution to exposure that originates from direct emissions from mobile sources, those which are photochemically produced from mobile source emissions, combustion processes, and contributions of other sources and environments which also contribute to these exposures. Data from the Global Positioning System (GPS) were collected and evaluated as a means of participant tracking. Supplemental data were obtained from indoor and outdoor pollutant monitors at the residences of the volunteers, from ambient pollutant and meteorological monitors at fixed-site locations in each city, from real-time diaries completed by the technicians and volunteers, and from questionnaires completed by the volunteers. The field design was model-based, that is, the monitoring field data were gathered for

input into the model or to test and validate modeled predictions. Measured and predicted exposures will be compared for determining uncertainties of the modeled exposures.

Each field study (city) had two components. In the first component (Phase A), integrated personal exposures for 38 and 33 volunteers, for Sacramento and Milwaukee, respectively, were measured once during a summer season. This study is similar in design to other personal exposure studies except that the volunteers will be randomly chosen according to selection criteria related to location of residence. The study population was selected according to spatial gradients away from the downtown area. Twenty four-hour measurements of the corresponding indoor and outdoor concentrations at the residence of each subject were also made. In the second component (Phase B, "scripted") the exposures of a technician to the same set of pollutants was measured as the technician followed a set of prepared instructions, called scripts, to follow throughout the day.

These scripts outlined the activities and microenvironments to which the technician will be exposed on a given day, e.g., commuting downtown, driving in street canyons, walking inside, walking outdoors around a commercial area away from a roadway. The script provided instructions to the technician specifying (1) the duration of an air sample to be taken during each sampling period, (2) the general and microenvironmental location during the sampling period, and (3) the general activities undertaken during the period. Personal exposure monitors (aldehyde-DNPH, VOCs, and CO) were used to measure 1-hr and 12-hr exposures to each compound as the technician simulated the activity patterns of typical city residents. Using the data generated from the scripted study and information about the activities of the study participants in the personal monitoring study, the 24-hour exposures of the participants will be predicted using an existing EPA model, pHAP, and compared to those measured.

To date, all of the samples have been collected, analyzed, and assembled into a database that also contains the meta data. A series of stepwise linear regression (SLR) analyses were performed on these data to identify the factors that best predicted exposure to each pollutant. The aldehydes measured in Sacramento by microenvironment are shown in Figure 1. The highest concentrations of aldehdyes were found indoors at a restaurant, indoors at a residence, transportation in a car, indoors at a grocery store, and outdoors within 10 yards of the roadway. The percent of the variability for formaldehyde and acetaldehyde explained by the microenvironment is shown in Table 1. Much higher total correlations were observed for formaldehyde.

For comparison, the aldehyde concentrations measured in various microenvironments in Milwaukee are shown in Figure 2. The highest aldehyde median concentrations were found indoors at a store, indoors at a restaurant, and indoors at the technician's residence. Analogous SLR analyses have not yet been performed for Milwaukee. This information will be of use to the U.S. EPA in determining the significance of microenvironment on human exposure.

VI. Some lessons learned.

Indoor exposures to formaldehyde and acetaldehyde are higher than outdoor exposures, especially in areas with food and food preparation.

Further lessons await completion of the data analysis.

Figure 1. Sacramento Study Aldehyde Results. (n = number of total observations; IND = indoors, OUT = outdoors; c.f. Table 1)

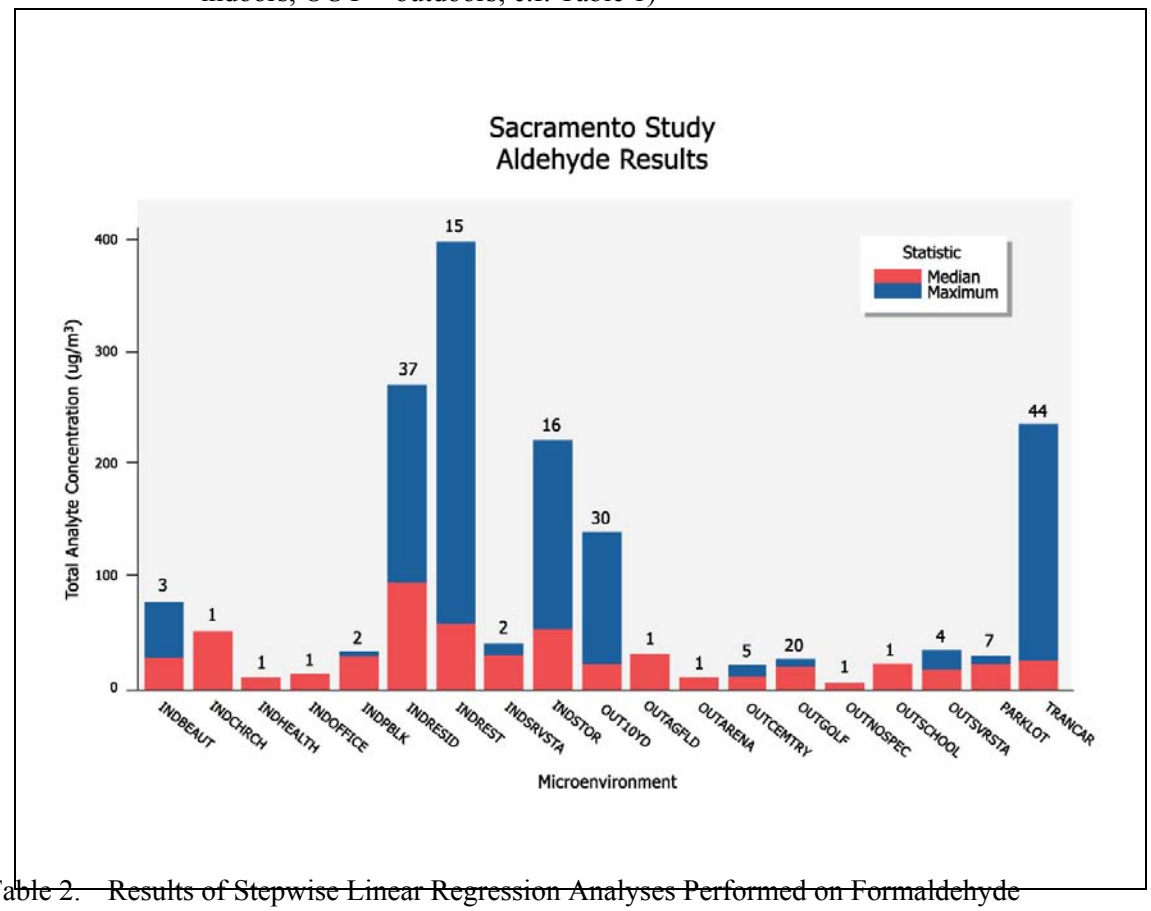

Table 2. Results of Stepwise Linear Regression Analyses Performed on Formaldehyde and Acetaldehyde Concentrations - Sacramento Scripted Activity Study

Compound	Binary Predictor Variable	Regression Coefficient	Cumulative R^2 Value
Formaldehyde	Constant	7.5	0.000
(n = 191)	Indoors - store	12.4	0.172
	Indoors - residence	13.0	0.354
	Indoors - auto parts store	29.8	0.433
	Indoors - restaurant	10.8	0.500
	Using solvents	34.5	0.558
	Smoke from forest fires	29.5	0.601
	Indoors - church	17.5	0.616
	Indoors - service station	11.5	0.629
	Indoors - furniture store	16.1	0.638
	Indoors - building supply store	10.0	0.650
Acetaldehyde	Constant	13.9	0.000
(n = 192)	Air conditioning on	26.0	0.238
	Drinking alcoholic beverage	25.1	0.292
	Indoors - grocery store	92.1	0.331
	Indoors - residence	22.6	0.360
	Eating	20.3	0.378

6. Minneapolis-St. Paul, MN

I. Project name and location, also project sponsor

A Comparison of Community, Residential, and Personal Exposure in Minneapolis-St. Paul, Minnesota
EPA STAR Grants R825241 and R827928

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III. Key questions addressed and purpose of the project

The purpose of this research was to estimate outdoor air concentrations of VOCs in the Minneapolis-St. Paul metropolitan area and compare them with outdoor, indoor, and personal monitoring. Based on preliminary modeling three neighborhoods were chosen for outdoor ambient, indoor, and personal monitoring. The modeled outdoor concentrations were then compared with the monitored outdoor concentrations to try to understand the reasons for agreement or lack of agreement. The modeling was done using the most commonly used EPA regulatory air dispersion model, ISCST3 (Industrial Source Complex Short Term version 3) and VOCs emission estimates from point, area, and mobile sources (mobile and area sources using 1997 and point using 1999 emission inventories). The point sources were modeled as point sources, and the area and mobile sources were resolved to the census tract level and modeled as area sources.

IV. Uses of modeling and monitoring

Only outdoor air VOC concentrations were modeled. Modeled concentrations were used to assist in selecting neighborhoods for outdoor, indoor, and personal monitoring. Three communities were selected: two (East St. Paul and Phillips) with relatively high and one (Battle Creek) with relatively low estimated ambient concentrations. Model estimates can be compared with outdoor measurements (matched in space and time) to provide information on model accuracy.

The monitoring data consisted of personal, indoor, and outdoor measurements of VOCs. The personal, indoor, and some outdoor measurements were made with personal organic vapor monitors (OVMs). Other outdoor measurements were made with sampling canisters analyzed by GC-MS (the Federal Reference Method). There were 75 non-smoking study participants

from three neighborhoods in the metropolitan area, each of whom had indoor (stationary residential) and personal measurements up to six times over three seasons. The monitoring data can be used to understand the relationships between indoor, outdoor, and personal VOC measurements. The data can also be used to look at the variability in indoor and personal measurements for a given home or person over time (i.e., longitudinal variability).

V. Key results:

- The OVM monitoring badges were an effective and relatively inexpensive method for obtaining 48 hour average VOC measurements for ~12 compounds;
- OVMs compared well with canisters for most VOCs in this study;
- Generally for measured VOCs: Personal > Indoor > Outdoor;
- Air dispersion modeling with ISCST reasonably predicted outdoor VOC concentrations if the emission inventory was accurate;
- The model tended to predict average concentrations and was less accurate at high or low concentrations. This is expected since the emissions inventory cannot capture the details of all of the temporal and spatial variability in emissions;
- The ISCST model performed best in Battle Creek (relatively simple emissions scenario) and worst in Phillips (more nearby and relatively complex emissions);
- The model failed to predict the higher VOC concentrations found in indoor and personal air.

VI. Lessons learned

Modeling can be effective in predicting outdoor concentrations of VOCs. The most critical model input is the emissions inventory—without an accurate inventory the model predictions are not reliable.

An indoor air model and a personal exposure model would be necessary to estimate indoor air concentrations and personal exposures more accurately. Indoor air modeling requires an accurate inventory of indoor air pollution sources, and personal exposure modeling requires an accurate assessment of each microenvironment encountered by the study subject as well as a record of the amount of time spent in that microenvironment. We collected time-activity information on these subjects, but have limited data on sources in these homes and no air exchange data for these households. We also do not have data on air concentrations in microenvironments outside the home.

The outdoor air modeling presented in this case study is regulatory state of the art. It would be possible to use a more refined model, but the accuracy of the emissions data doesn't warrant that level of sophistication at this time.

7. National Air Toxics Assessment (NATA)

I. Project name and location, also project sponsor
National Air Toxic Assessment - Initial National Scale Assessment

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III. Key questions addressed and purpose of the project
The National-Scale Air Toxics Assessment, which is based on 1996 emissions data, produced results that are useful in understanding the quality of air and its possible effect on human health nationwide. The assessment looked at 33 air pollutants (a subset of 32 air toxics from the Clean Air Act's list of 188 air toxics plus diesel particulate matter). The primary goal of the national-scale assessment was to identify those air toxics which are of greatest potential concern, in terms of contribution to population risk. The results will be used to set priorities for the collection of additional air toxics data (e.g., emissions data and ambient monitoring data).

IV. Uses of modeling and monitoring
The initial national-scale assessment is comprised of four major technical components: 1) compiling a national emissions inventory of air toxic and diesel PM for the year 1996 from outdoor sources; 2) estimating 1996 air toxics and diesel PM ambient concentrations; 3) estimating 1996 population exposures; 4) characterizing potential public health risks. .

The 1996 National Toxics Inventory (NTI) is the underlying basis for the 1996 emissions used in the national-scale assessment. The NTI contains air toxics emission estimates for four overarching source types: major, area and other, onroad mobile, and nonroad mobile.

To develop nationwide estimates of annual average ambient concentrations of air toxics, EPA used the Assessment System for Population Exposure Nationwide (ASPEN) model (developed and used in EPA's Cumulative Exposure Project). The modeling domain for the national modeling effort is the contiguous United States, Puerto Rico and the Virgin Islands. The ASPEN model, which is based on the ISCLT2 dispersion model, estimates annual average ambient concentration of each air toxic pollutant at the centroid of each census tract within the geographic domain. In an effort to apply a "reality check" on the ASPEN estimates, results were compared to available ambient air monitoring data. EPA selected a representative subset of seven air toxics (benzene, perchloroethylene, formaldehyde, acetaldehyde, cadmium, chromium, and lead) mainly because these air toxics have the largest number of monitoring sites. In general the ASPEN model was found to underpredict impacts for most components.

The HAPEM4 model has used to predict the nationwide inhalation exposures. Through a series of calculation routines, the model makes use of census data, human activity patterns, ambient air quality levels, climate data, and indoor/outdoor concentration relationships to estimate an expected range of "apparent" inhalation exposure concentrations for populations of concern. The final step in the assessment include characterizing both cancer and noncancer effects on public

health due to inhalation of study air toxics.

V. Key results (and were the results useful to the sponsor?)
The assessment developed a list of national priority air toxics. The pollutants that are predicted to have the greatest impact upon the largest number of people include: Benzene, Chromium, Formaldehyde, Acrolein. In general results of the assessment will be used for: identify air toxics of greatest potential concern; set priorities for collection of additional air toxics data at the EPA, state, local, and tribal level; roughly characterize the relative contributions to air toxics concentrations and population exposures of different types of air toxics emissions sources (e.g., mobile, large industrial, smaller industrial); establish a baseline for tracking trends over time in modeled ambient concentrations of air toxics; and establish a baseline to measure progress toward meeting goals for reductions of inhalation risk from ambient air toxics.

VI. Lessons learned (and what would you have done differently?)
A detailed peer review of the assessment by the SAB identified both the scientific strengths and weakness of the assessment. One possible lesson learned involved communicating the results of the assessment and assuring that these results are not misused. It is important that limitations and uncertainty on the data be defined and presented along with the results to prevent misuse or overuse of the studies results.

8. Portland, OR

I. Project name and location, also project sponsor

Portland Air Toxics Assessment (PATA); Portland, OR (Multnomah, Clackamas and Washington counties); Oregon DEQ, METRO, USEPA (OTAQ and OAQPS)

II. Contact name, institution, address, phone number, email address

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Arlene Rosenbaum and Ed Carr, ICF Consulting

III. Key questions addressed and purpose of the project

Project will help Oregon develop and implement risk/geographic-based air toxics program/rules. Goal is to have modeled and monitored data with risk characterization to help identify and prioritize risk reduction strategies.

IV. Uses of modeling and monitoring

Five urban monitoring sites in place from 1999 - 2001; refined stationary and mobile (emissions allocated to major roads) inventories for 1999 will be used to run CALPUFF; HAPEM5 will be run with ambient results; CALPUFF outputs will be compared with monitoring data to validate model. Modeled and monitored ambient data and risk characterization will be used to compare to the National Scale Assessment.

V. Key results (and were the results useful to the sponsor?)

Monitoring information and 1996 National Scale Assessment results were used to identify pollutant drivers for project scoping. Plan to have modeled and monitored data and comparison with monitored values to be completed by September 30, 2002.

VI. Lessons learned (and what would you have done differently?

9. Port Neches, TX, Calcasieu, LA, and Little Rock, AK

Air Toxics Local Scale Assessment Case Studies

I. Project name: Regional Air Impact Modeling Initiative: Pilot Studies - Initial Phase

Locations: Port Neches, Texas
Calcasieu, Louisiana
Little Rock, Arkansas

Project Sponsor: U.S. EPA Region 6

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III. Key questions addressed and purpose of the project

The U.S. Environmental Protection Agency (EPA), Region 6, has established a regional air impact modeling initiative (RAIMI) pilot program for estimating the combined health risks to individual receptors within a neighborhood as a result of aggregate exposure to multiple contaminants from multiple sources and multiple exposure pathways. The initial phase includes the estimation of potential aggregate inhalation risks associated with modeled air concentrations from significant local emission sources within the Port Neches Assessment Area, Jefferson County, Texas.

The overall strategy for completing the RAIMI pilot study was conceived to efficiently maximize the usefulness of existing guidance, risk assessment tools, and databases to suffice the following project design goals:

- Useful as a permitting tool to support EPA, state, and local permitting authorities–independently or combined–evaluate and demonstrate protectiveness of cross program permitting decisions and support holistic, tailored permit strategies with the flexibility to be either area (i.e., industrial complex), facility, or source-specific;

- Provide a standardized and consistent means by which all permitting authorities could account for and assess aggregate health effects to multiple contaminants from multiple sources, which are often subject to multiple permitting schemes, but cumulatively impacting the same receptor neighborhoods;

- Provide the necessary level of detailed information to prioritize, and simultaneously begin identifying potential solutions, for sources resulting in unacceptable risks by estimating combined health effects resulting from multiple contaminants and sources, but at a community level of resolution that is specific to definable individual locations, and generated in a fully transparent fashion such that aggregate risk levels are completely traceable to each contaminant, each pathway, and each source;

- Calculate and track risks from literally hundreds of sources and contaminants based on actual emissions data submitted by facilities to the state agency, and as new or refined data becomes available, it can be directly incorporated into the assessment to obtain revised risk estimates on practically a real time basis;

- Serve as a versatile and dynamic project platform, allowing for the rapid identification, characterization, assessment, and management of aggregate environmental exposures that pose the greatest health risks to the public.

IV. Uses of modeling and monitoring

1. North Little Rock, Arkansas: Modeling was used to evaluate chronic exposure at the site. Monitoring was used in conjunction with modeling to select locations to evaluate acute exposure at the site.

2. Calcasieu, Louisiana: Modeling used to cite monitors and track emissions which exceed state standards to their sources of origin.

3. Port Neches, Texas: Canister monitors had identified the area as a chronic exposure problem for over ten years. Mobile monitoring verified the canister results and also indicated acute exposure problems. Modeling was used to track measured emissions back to their source(s). A monitoring to modeling study conducted with this study reveled data gaps associated with the emissions inventory for both source location and estimated emission rates. Also, uncertainties were found to be associated with both monitoring and modeling. The magnitude of the effects of data gaps and uncertainties was found to be chemical- and site-specific. When data gaps were filled for two of the major chemicals emitted in the area, modeling to monitoring comparisons were within 15% of each other.

V. Key results (and were the results useful to the sponsor?)

Major program changes for which specific, immediate benefits of the application of the RAIMI include:

1. Prioritization of resources based on the contribution to human health risk (management of "worst first")
2. Improved community outreach and involvement by allowing citizens access to more comprehensive environmental analysis
3. Objective, scientific basis for evaluating new facility sitings, operational modifications and plant expansions

The RAIMI studies completed to date have focused on evaluation of volatile organic compounds released to the air over three specific communities. Data generated from application of the RAIMI facilitated regulatory decisions that focused on environmental benefits.

1. North Little Rock, Arkansas, had a history of citizen complaints surrounding a creosote plant.

- One facility, multiple emission sources
- No significant potential health impacts identified
- Odor problem existed, naphthalene identified
- Based on modeling, State elected not to pursue additional permit requirements.

2. Calcasieu, Louisiana had been identified by the National Environmental Justice Advisory Committee as an area of high concern. The Agency of Toxic Substances Disease Registry had measured dioxin levels above background in residents' blood.

- 18 major facilities, 2500 point sources
- RAIMI modeling used to validate placement of air monitors and to track excessive monitored air pollution back to individual sources.

3. Port Neches, Texas had excessively high monitored concentrations of air pollutants dating back over 10 years.

- 16 major facilities, 1500 point sources
- RAIMI modeling used to locate specific emission source(s) that resulted in excessive monitored air toxics. Prioritization of permitting and enforcement actions was narrowed to focus on two facilities and three individual sources.

VI. Lessons learned (and what would you have done differently?)

A review of the design goals at the end of the Pilot Study indicates that design goals were substantially achieved as RAIMI provide:

- A flexible mechanism to consider a range of risk management alternatives to ensure protectiveness;
- A standardized and consistent means to prioritize sources based on risk impacts;
- A sound methodology ensuring that each elemental component of risk or modeled air concentration is fully traceable to the culpable source; and
- The flexibility to be revised as new or more complete emissions data sets become available.

Certain of these design goals could be more fully achieved, however, given the following:

- Emissions inventories that are more complete, particularly with regard to emissions speciation, and inclusion of emissions from minor sources, would significantly increase confidence in results;
- Data management tools could be developed and incorporated into the RAIMI approach to improve the ability to access, compare, manipulate and revise data among the emissions characterization data sets, air dispersion modeling results and risk modeling results;
- Aspects of the technical approach can be modified to reduce the amount of extraneous data generated.

10. San Francisco Bay Area

I. Title: Characterization of Urban Air Toxics Sources in Support of HAPs Emission Control Strategies. Location: SRI International, Menlo Park, CA. Sponsor: EPA Office of Research and Development, National Center for Environmental Research, under STAR grant R827927, Deran Pashyan COTR.

II. Contact: Dr. Michael J. Coggiola, SRI International, Menlo Park, CA, 650-859-3045, michael.coggiola@sri.com

III. This research program leverages SRIÕs development of a continuous emissions monitor (CEM) for dioxins and furans supported by the U.S. Department of Energy (DOE). The detector uses a pulsed nozzle gas inlet, resonance enhanced multiphoton ionization (REMPI), and time-of-flight mass spectrometry (TOF-MS). Using this Jet-REMPI approach, detection limits in the low 20 parts-per-trillion have been obtained. The extreme sensitivity and chemical specificity of this instrument, and the nearly universal nature of REMPI and mass spectrometry, provide a new analytical capability. With a single instrument, the spatial and temporal distribution of a majority of the most toxic organic HAPs can now be concurrently measured at levels that are of toxicological interest.

IV. This instrument will provide direct detection and identification of the most HAPs and HAP mixtures in urban air in real time, i.e. one to several minutes of averaging. The objectives in this combined laboratory and pilot field study are to establish a viable means of measuring the emission rates, and temporal and spatial distributions of urban air toxics and HAPs using our ultra-sensitive, CEM. Because our CEM is capable of directly measuring in real-time the concentration of specific HAPs and urban air toxics at levels far below present analytical instruments, we can potentially identify and characterize critical emission sources over a wide geographical area under a variety of ambient monitoring conditions.

V. SRIÕs spectral library now includes more than 120 compounds, including many of the most common urban air toxics. Using this library, we have begun a preliminary local field study by collecting urban air samples onto sorbent tubes for off-line analysis. We anticipate that these analyses will ultimately allow us to not only improve the sampling and analysis protocols, but also to establish some approximate air toxics levels in the San Francisco Bay Area. This latter data will permit us to determine if our current instrumental sensitivity is sufficient for real-time field measurements, or if further improvements will be required to acquire this type of field data.

To test our sampling and analysis approach, samples were taken from a variety of sources, including automobile exhaust, and ambient air. In ambient air, we collected samples on a carbon filter element for 3.5 hours, to obtain enough sample to use GC/MS as a survey tool. Only toluene shows in the GC/MS scan as a small signal. To use Jet-REMPI, we diluted the same sample by a factor of 20,000 to avoid overloading the instrument. This dilution is equivalent to a direct measurement with a sampling time of about 1 sec. All of the BETX (benzene, toluene, ethyl benzene, and the xylenes) compounds were readily seen in the Jet-

REMPI instrument, and the three isomers of xylene could be individually quantified. Our preliminary study showed that not only can many urban air pollutants, such as BETX, be detected quantitatively using Jet-REMPI combined with long-term sorbent sampling, but more importantly, because of the high sensitivity of REMPI, these same compounds could also be detected in the field in near real-time without preconcentration.

In parallel with the urban air sampling effort, we have also performed a pseudo-field study with support from the Department of Energy. SRI had a unique opportunity to perform a series of pseudo-field measurements without the time and expense associated with transporting the instrument to a field site. This was possible by using the REMPI apparatus that SRI built for Dr. Brian Gullett at the EPAÕs NRMRL. Since that apparatus is essentially a duplicate of the one currently in use at SRI, measurements taken with the system in conjunction with EPAÕs combustion facility allowed us to make these Òfield-likeÓ measurements. Among the most intriguing observations was the detection of several interesting species that were identified in a nominally ÒcleanÓ methane flame. Benzene and phenol (at 150 ppt) were both positively detected in the off-gas stream of the reactor. In addition, clear evidence was also found for aniline produced in the EPA reactor under the test conditions. For all species, the measured spectra are essentially identical to those recorded using a ÒcleanÓ test gas mixture and all were easily detected in the exhaust stream. Furthermore, their presence could be entirely attributed to the methane combustion chemistry as the background levels were not detectable in the absence of the flame.

This study further demonstrated the usefulness of Jet-REMPI for rapidly detecting and identifying organic species at trace levels under Òfield-likeÓ operating conditions.

VI. There are several important lessons learned from both of these simple studies. It seems clear that our new analytical method is very well suited to measuring air toxics with high temporal and spatial resolution. Our current instrument, however, is much too large and bulky to take to the field. In addition, it is clear that more effort is required to develop a direct air sampling inlet suitable for field studies. SRI is currently pursing the development of a more compact Jet-REMPI system based on a variety of commercial components, including fixed frequency and broadband tunable laser systems, and compact time-of-flight mass spectrometers. Once developed, such a system could be very useful in field studies of urban air toxics.

11. South Coast Air Quality Management District, CA

I. Project name and location, also project sponsor

Multiple Air Toxics Exposure Study (MATES-II) in the South Coast Air Basin of California.

II. Contact name, institution, address, phone number, email address

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http://www.aqmd.gov/matesiidf/matestoc.htm
http://www.aqmd.gov/matesiidf/chapter2.doc
http://www.epa.gov/ttn/chief/conference/ei10/toxics/nazemitoxics.pdf

III. Key questions addressed and purpose of the project

This was a Environmental Justice (EJ) study involving many stakeholders.

IV. Uses of modeling and monitoring

Four Counties (several 1000 sq km); modeling was done at a local scale as well**.** Two of the three neighborhoods were about 4 km squares; the third was about a 2-3 km square.

V. Key results (and were the results useful to the sponsor?)

There were three main components: Monitoring; Emission Inventory Development; and Modeling. The monitoring effort was an enhancement of existing South Coast monitoring in the area (increase in number of sites and sampling frequency). Monitoring spread across a four county region from April 1998 - March 1999. Looked at 30 plus pollutants.

Monitoring network were not dense enough to answer EJ issues or provide culpability. Thus they supplemented with modeling. First developed a detailed emission inventory. Modeled study area with Urban Airshed Model (UAM) at a 2km resolution. Also did microscale modeling using ISCST3. Study showed diesel PM (DPM) was biggest health concern for air toxics. Also looked at results without DPM.

VI. Lessons learned (and what would you have done differently?)

The biggest lesson appeared to be one of communication issues with the many stakeholders involved; especially as the project wound down.

12. Barrio Logan, San Diego, California

Project Name: Barrio Logan

Project Location: San Diego, California

Project Sponsor: California Air Resources Board

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The Barrio Logan Pilot Study was developed to address concerns about air quality in a predominantly minority and low-income community in San Diego, and to begin to develop monitoring and modeling protocols for evaluating environmental justice concerns.

The Barrio Logan community of San Diego was selected for study because it is located in a large urban area, near major freeways and industrial sources, as well as neighborhood sources such as gas stations, dry cleaners and automotive repair facilities. In the initial phase of the study, ARB conducted ambient air quality monitoring at the Memorial Academy Charter School. Monitoring began in October 1999 and concluded February 2001. Results from the first six months of data suggested toxic and criteria pollutant concentrations were similar to those measured in other urban areas of San Diego. Further analysis on all monitoring results are currently being conducted.

The Barrio Logan Pilot Study is also the first to be conducted for ARB's Neighborhood Assessment Program (NAP). The goals of the NAP are to assess the cumulative impact of air pollution sources on communities and to develop guidelines for evaluating strategies for reducing air pollution impacts at a neighborhood scale. In order to estimate air pollutant concentrations, ARB staff developed an approach using regional (UAM, Models-3) and micro-scale (ISCST3, AERMOD) air quality models to assess ambient and near-field pollutant concentrations. Model results are currently being evaluated using tracer measurements, additional air toxics monitoring, and uncertainty analysis.